

# On the Production of a 'Dark Cross' in the Field of Electro-magnetic Radiation

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"On the Production of a 'Dark Cross' in the Field of Electro-magnetic Radiation." By JAGDIS CHUNDER BOSS, M.A., D.Sc., Professor of Physical Science, Presidency College, Calcutta. Communicated by Lord RAYLEIGH, F.R.S. Received February 14,—Read March 10, 1898.

A circular piece of chilled glass when interposed between crossed nicols produces a dark cross. A similar effect is produced by crystals like salicine where there is a radial disposition of the principal planes.

I have been able to detect a similar phenomenon in the field of electric radiation by the interposition of an artificial structure between the crossed polariser and analyser.

I have in a previous communication described the polarisation produced by the leaves of a book. For the following experiment, a long strip of paper was rolled into a disc. A roll of Morse's tape serves the purpose very well. The diameter of the disc is 14 cm. and its thickness 2 cm. It will be observed that here we have a single axis passing through the centre, and that all planes passing through the centre are principal planes.

The effect produced by the interposition of the structure may be studied by keeping the disc fixed and exploring the different parts of the field by means of the detector; or the detector may be kept fixed (opposite the analyser) and the disc may be moved about so that the different parts of the field may successively be brought to act on the detector. This latter plan was adopted as being simpler in practice.

The arrangement of the apparatus is the same as in fig. 1 of my paper "On the Rotation of Plane of Polarisation of Electric Waves by a Twisted Structure." The polariser is vertical and the analyser horizontal. The paper disc is interposed between the screens with its plane at right angles to the direction of the ray.

The receiver is fixed on the prolongation of the line (which I shall call *the axis*), joining the centres of the polariser and the analyser.

On the supposition that the interposition of the disc produces a dark cross, the arms of the cross (with the particular arrangement of the polariser and the analyser) will lie in the projections of the vertical and the horizontal diameters of the disc, and will move in space with the movements of the disc. When the centre of the disc is on the axis the intersection of the cross will be superposed on the receiver, and there should then be no action. If the disc be moved up and down, the centre remaining in the vertical line passing through the axis, the vertical arm of the cross will slide over the receiver. If the disc be moved laterally, with its centre in the horizontal line passing through the axis, the horizontal arm of the cross will slide over the receiver. In this, as in the last case, there should be no action on the receiver. But if the disc be displaced so that the centre does not lie in either the horizontal or the vertical line passing through the axis (the axis now cutting the disc at points such as *a*, *b*, *c*, or *d*), the arms of the cross will not fall on the receiver, and there should be a response in the receiver.

The experiments were now arranged as follows:—The disc was at first placed with its centre on the axis, the plane of the disc being

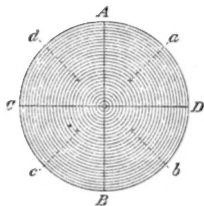


FIG. 1.—The paper disc. AB, CD are the vertical and horizontal diameters.

perpendicular to the axis. There was now no action on the receiver; but as soon as the disc was tilted, however slightly, an action was immediately produced on the receiver.

The disc was now mounted on a stand, between the two screens. By means of sliding arrangements the disc could be raised or lowered, or moved laterally.

In the next experiment, the centre of the disc was first adjusted on the axis, and the disc moved vertically up and down. No effect was produced when this was being done.

The centre of the axis was again adjusted on the axis, and the disc moved laterally on the horizontal slide. In this case, too, there was no action.

By adjusting the vertical sliding rod the centre of the disc was next placed vertically above or below the axis. The disc was then moved laterally either to the right or to the left. In this way the

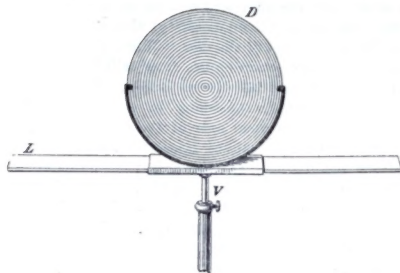


FIG. 2.—The holder for the disc. D, the paper disc. V, L are the vertical and horizontal slides.

field could be displaced, and the quadrants *a*, *b*, *c*, or *d* (see fig. 1) placed opposite to the receiver. In all these cases, even with small displacements, very strong action was produced on the receiver.

From experiments carried out in the manner described above, the outline of a dark cross projected in space was distinctly made out.

A disc of wood, with *concentric rings*, would probably show the effect equally well. I shall in a future paper send an account of the action of crystals cut perpendicular to the axis placed in convergent or divergent beams of electric radiation.

Some of the investigations on the rotation of the plane of polarisation will, perhaps, be facilitated by an observation of the rotation of the cross. By a modification of this method I am at present trying to detect the rotation produced in a magnetic field.

Addendum, 16th March, 1898.

The production of a dark cross can also be demonstrated by interposing between the crossed polariser and analyser concentric rings of tin-foil mounted on a thin sheet of mica. But greater interest is attached to the exhibition of the phenomenon by double refracting substances, where the axes of elasticity are disposed in radial directions. From the peculiar stresses present, I surmised that woody stems with concentric rings would exhibit the phenomenon above described. Through the kindness of Dr. Prain, I obtained from the Government Botanical Gardens, Sibpore, stems of *Pinus longifolia*, *Swietenia mahogani*, *Araucaria Cunninghamii*, *Mangifera indica*, *Casuarina equisetifolia*, *Cupressus torulosa* and *Dalbergia sissoo*. The ring systems present in some of these were very regular, I was, however, at first disappointed in failing to obtain the results anticipated. But this failure, I subsequently found, was due to the general opacity of the wood which was freshly cut, and which, though apparently dry, contained large quantities of sap in the interior. I then carefully dried some of the specimens, when the stresses present became quite apparent by numerous cracks starting in radial directions. The results obtained with these dried specimens were quite satisfactory.

I now tried to devise some experiments strictly analogous to the optical experiments with chilled glass. For this purpose I cast a cylinder of paraffin wax in a metallic mould surrounded by a freezing mixture. Owing to the great contraction produced by solidification, a hollow depression was formed in the centre, and this produced a distortion of symmetry. It would, therefore, be better to build up a cylinder by successive dippings, the deposited molten layer contracting on the solid core. I obtained, however, extremely good results with a cylinder of cast ebonite, in which the stresses present are exactly similar to those in a circular piece of unannealed glass.

The next series of experiments were undertaken with mineral specimens. I here acknowledge with thanks, the kind help I received from Mr. Hayden, B.A., and Mr. Blyth, of the Geological Department, in obtaining suitable specimens for my experiments. One very interesting specimen obtained from Egypt was formed by ringed concretion of flint round a central nodule. This specimen exhibited the cross with great distinctness. I also obtained fairly satisfactory results with stalactite. The concretion of calcium carbonate formed inside a pipe by deposits from temporarily hard water flowing through it, would also be found to exhibit this phenomenon.

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